

at most stations to 10.00 at Harbor. The drought is one of the severest on record. Frosts occurred at various points every day, except the 5th, and were mostly heavy enough to kill tender vegetation.

Oklahoma.—The mean temperature was 56.9°, or 4.6° below the normal. The highest temperature, 96°, was recorded at Lehigh on the 16th, and the lowest, 21°, at Lehigh on the 28th. The average precipitation was 3.14, or 0.42 above the normal amount. The greatest monthly amount, 4.59, occurred at Fort Sill, and the least, "trace," at Lehigh. Frosts occurred on the 1st, 9th, 12th, 13th, 19th, 20th, 21st, 24th, 25th, 28th, and 31st.

Oregon.—The month was phenomenally dry; in fact, the driest ever experienced within the memory of any pioneer. The average temperature was 53.6°, or 1.6°, above the normal. In the eastern part, however, the temperature was decidedly higher than the average. The highest temperature, 92°, was recorded at Canyon City on the 15th, and the lowest, 6°, at Burns on the 29th. The average precipitation was 0.09, being 3.65 less than, or about 2½ per cent of the usual amount. The greatest amount for the month, 1.37, occurred at Glenora, and the least, 0.00, at eight stations west of the Cascades, and twelve east of them. Frosts occurred at one or more stations on every day except the 1st, 2d, 3d, 5th, 6th, 8th, and 10th to 13th.

Pennsylvania.—The mean temperature was 47.3°, or 2.9° below the normal. The highest temperature, 78°, was recorded at Coatesville on the 3d, South Bethlehem on the 5th and 6th, and at Huntingdon on the 19th, and the lowest, 17°, at Dyberry on the 22d, Hollidaysburg on the 23d and 30th, and Huntingdon on the 30th. The average precipitation was 1.99, or 1.65 less than the normal. The largest monthly amount, 4.63, occurred at Easton, and the smallest, 0.45, at Davis Island Dam. The long continued drought extended until the 12th or 13th, when the surface drought was practically broken in the Delaware Basin and in the eastern portions of the Susquehanna Basin. Heavy rains occurred again in these sections on the 31st. In the Ohio Basin the drought continued, the total rainfall for that section averaging only 0.90. Previous to the breaking of the drought in the Delaware Basin the water in the Delaware River at Philadelphia was quite brackish. Hail occurred on the 8th and 31st; snow, on the 9th, 15th, 17th, 20th, 21st, 22d, 27th, 29th, 30th, and 31st.

Rhode Island.—(See *New England*.)

South Carolina.—The weather conditions were extremely favorable for gathering crops, especially corn and cotton, but were unfavorable for pasturage and late root crops. Streams were low, and some wells went dry. The mean temperature was 61.5°, or 2.7° below the normal. The highest temperature, 95°, was recorded at Gillisonville on the 7th, and the lowest, 28°, at Greenwood on the 31st. The average precipitation, 1.15, was 1.95 below the normal, or about 37 per cent of the usual amount. The greatest monthly amount, 2.71, occurred at Society Hill, and the least, 0.09, at Allendale. Frosts occurred on the 1st, 7th, 10th, 19th, 20th, 21st, 22d, and 24th. That on the 20th and 21st in the western counties killed vegetation; in other sections the injury by frost was slight.

South Dakota.—The month was unusually dry, the effect on streams and shallow wells being quite noticeable. The weather was, however, generally favorable for the late thrashing of small grain and stock feeding on the ranges. The mean temperature was 45.0°, or about 2° below the normal. The highest temperature, 89°, was recorded at Cherry Creek (Leslie P. O.) on the 12th, and the lowest, 11° below zero, at Shiloh, on the 29th. The average precipitation was 0.20, or 1.14 less than the usual amount. The greatest monthly amount, 0.60, occurred at Bowdle, and the least, "trace," at five stations.

Tennessee.—The mean temperature was 53.4°, or several degrees below the normal, and is the lowest recorded during the past thirteen years. The highest temperature, 89°, occurred at Harriman on the 19th, and

the lowest, 22°, at Elizabethton on the 30th. The average precipitation was 1.89, or nearly 1.00 less than normal. The greatest monthly amount, 4.20, occurred at Sewanee, and the least, 0.60, at McKenzie. The drought was partly broken on the 7th and 8th, but it was not until the 31st that general soaking rains prevailed. Frosts and thin ice were reported from various stations throughout the State from the 1st to the 31st.

Texas.—The temperature averaged 4.1° below the normal. There was a general deficiency of temperature throughout the State. The highest was 96°, at Houston, on the 18th, and the lowest, 30°, at Wichita Falls, on the 8th. The precipitation was very irregularly distributed, but averaged only about 0.04 less than the usual amount. The greatest monthly amount, 6.86, occurred at Temple, and the least, 0.00, at Fort Ringgold. Frosts occurred on the 13th, 14th, 15th, 19th, 20th, 28th, 29th, and 31st.

Utah.—The mean temperature was 49.2°; the highest recorded, 95°, occurred at St. George on the 2d, and the lowest, 10°, at Castle on the 31st, and at Soldiers Summit on the 29th. The average precipitation was 0.56. The greatest monthly amount, 1.28, occurred at Grover, and the least, 0.04, at Logan. Snow, to the depth of 1.5 fell at Moroni, and inappreciable amounts at Grover and Loa.

Vermont.—(See *New England*.)

Virginia.—The month did not show any great variations in temperature, but preserved a rather uniform condition throughout. There were local changes where the range was considerable, but for the State, as a whole, no great changes are apparent. The mean temperature was 52.5°; the highest was 87°, at Bob Air, on the 4th, and the lowest, 14°, at Blacksburg on the 30th. The average precipitation, 1.71, was somewhat below the normal, though it fell in a very beneficial manner—a series of gentle showers. The greatest monthly amount was 4.15, and occurred at Birdsneat, and the least, 0.16, at Monterey. Frosts occurred on the 1st, 2d, 3d, 4th, 9th, and 10th, and ice on the 1st, 2d, 3d, 4th, 10th, 21st, 22d, 29th, and 30th.

Washington.—The mean temperature was 50.9°, or only 0.7° above the normal. The highest temperature was 85°, at Centerville on the 9th, and at Kennewick on the 13th, and the lowest, 12°, at Fort Spokane on the 27th. The average precipitation, 0.33, was 2.63 less than the usual amount. The greatest monthly amount was 1.70, at Monte Cristo, and the least 0.00, at several stations.

West Virginia.—The mean temperature was 48.0°, or about 5° below the normal. The highest temperature recorded was 89°, at Nuttallburg and Pennsboro on the 4th, and the lowest, 8°, at Nuttallburg on the 31st. The rainfall was extremely light, the average, 1.29, being about 2.00 less than the usual amount. The greatest monthly amount was 2.25, and occurred at Beverly, and the least, 0.16, at Harpers Ferry. Snow occurred on the 7th, 8th, and 9th, and sleet on the 31st.

Wisconsin.—Low midday and cold night temperatures, below the freezing point, prevailed generally throughout the month, rendering it the coldest October on record. The mean temperature was 41.9°, or 6.0° below the normal. The highest temperature reported was 80°, at Grantsburg on the 4th, and the lowest, 1.0°, at Valley Junction on the 30th. The average precipitation was 0.84, or 1.89 less than the usual amount. The greatest monthly amount was 1.40 at Koepenick, and the least, 0.04, at Grantsburg. The rainfall was not only deficient but was poorly distributed. The general droughty conditions continued; lakes and streams were drying up and forest and marsh fires increasing in number and extent. Snow fell during the last week and was from 1.00 to 4.00 deep over the northern portion at the close of the month.

Wyoming.—The mean temperature was 45.0°, or about normal. The highest temperature reported was 89°, at Wheatland on the 1st, and the lowest, 9°, at Lusk on the 28th. The average precipitation was 0.70, also about the usual amount. The greatest monthly rainfall was 2.00, at Wheatland, and the least, 0.00, at Lusk.

SPECIAL CONTRIBUTIONS.

REPORT UPON THE EARTHQUAKE OF OCTOBER 31, 1895.

By C. F. MARVIN, Professor of Meteorology, U. S. Weather Bureau.

An earthquake of sufficient severity to arouse many persons from sleep and otherwise attract notice occurred shortly after 5 a. m. ninetieth meridian time, of October 31. The damage resulting therefrom was confined to the overthrow of some chimney tops, the cracking of walls of brick or masonry buildings, the falling of plaster, and the breaking of household ornaments, etc. The disturbance was felt over a comparatively extensive region, embracing New Mexico and Nebraska on the west, some portions of Canada on the north, Louisiana and Georgia on the south, and North Carolina and the District of Columbia on the east.

Without special solicitation of information relating to this earthquake, the Weather Bureau has received through its

corps of observers, and from the Geological Survey and a few other sources, about 300 reports, abstracts of which are given at the close of this account.

Earlier shocks.—An earthquake on October 11 was reported by several observers, as follows:

A. S. Ammerman, Rochford, S. Dak.: At 5.55 p. m.; lasted seven seconds; a low rumbling noise; only one shock felt; intensity light, on a scale of 5; appeared to travel from northwest to southeast.

P. Haunnerquist, Farmingdale, S. Dak.: Lasted about one minute; like a wagon going past the house; intensity very light.

W. H. Zimmerhoff, Hill City, S. Dak.: At 7.30 p. m.; lasted two or three minutes; rumbling like a heavy wagon; only one shock felt; intensity light.

Fred. J. Cross, Keystone, S. Dak.: Felt at 7.15 p. m. sun-

time (longitude $103^{\circ} 22'$; therefore, this apparent solar time is equivalent to 8.08 p. m., ninetieth meridian time); lasted about ten seconds. The shock was preceded by a rushing or hissing sound for three or four seconds, like the wind blowing through brush. It was followed by a rumbling sound, similar to a heavy wagon on hard ground; this lasted two or three seconds; then came this heavy jarring shock; two shocks were felt. The workmen on the night shift in the mills and mines say that there was another shock about 3 a. m. of the 12th. The intensity was 3, or moderate, on a scale of 5.

Mr. Jacob Brobst, the voluntary observer at Corning, Clay Co., Ark., reports that light shocks of earthquake were felt on October 30, at 8.30 a. m., and at 2 and 4.30 p. m., in addition to the heavy shock on the morning of the 31st.

Messrs. Powell and Hammel, the voluntary observers at New Madrid, New Madrid Co., Mo., report the occurrence of two light shocks on October 18 at 12.10 and 3 a. m.; also, the severe shock of October 31.

Whether these disturbances were real earthquakes and related in any way to the greater shock of the 31st, or were in any cases accidental local disturbances supposed to be earthquakes, is difficult to determine.

Causes of earthquakes.—Concerning the causes of earthquakes, Professor Abbe remarks as follows:

According to views commonly accepted in geology, the so-called solid crust of the earth consists of an unknown depth of granite and gneiss, on top of which are 5 or 10 miles of metamorphic and sedimentary strata. This crust is everywhere in a state of strain, due to various kinds of stress; in other words, the outward bulgings that make the continents and the mountain ranges, or the downward bendings that have made the ocean beds, represent strains that frequently become too severe for the rocks to resist. Moreover, in special localities there are upward-pressing masses of lava or other plastic material that produce great local strains. In other places the strata that ages ago were tilted up to make a mountain are still in a state of strain, and, notwithstanding the long interval that has elapsed, are occasionally cracking and sliding on each other. These various stresses have produced the innumerable cracks that we see in the smaller beds of rock and the faults that the miner discovers in his attempt to follow up a vein of mineral ore. Even the tidal action of the sun and moon and the variations in barometric pressure and in the loads of snow and alluvium can produce appreciable effects.

Small cracks, with attendant shocks, are continually occurring everywhere throughout the globe. Some localities are famous for mysterious noises that have almost in every case been traced to the sudden cracking of rocks near the surface. Such are the famous Moodus noises at the town of that name in Middlesex County, Conn., where the Salmon River empties into the Connecticut River. Such sounds are heard at the famous gneiss quarries of Monson, Hampden County, Mass.; whenever a large piece of rock is loosened, loud, crackling noises are produced. On the slopes of Black Mountain, N. C., in 1876, many mysterious noises were heard, until, finally, it was discovered that a large portion of rock was crackling and settling.

In a recent number of *Nature*, Vol. LIII, p. 4, Professor Davidson remarks on these slight earthquakes as follows:

Is it not possible that the "Berisal guns" and "mist puffers," referred to by Professor Darwin (p. 650), are merely earthquake sounds, the attendant shock being too slight to be otherwise perceptible? Nearly all earthquakes are accompanied by a rumbling sound, due, I believe, to the small and rapid vibrations proceeding chiefly from the margins of the area over which the fault-slip producing the earthquake takes place. (*Geol. Mag.*, Vol. IX, 1892, pp. 208-218.) In some districts (Comrie, in Perthshire; East Haddam, in Connecticut; Pignerol, in Piedmont; Meleda, in the Adriatic, &c.) sounds without shocks are common during intervals which may last for several years, but slight shocks with sound occasionally intervene, as if the sounds and shocks were manifestations, differing only in degree and the method in which we perceive them, of one and the same phenomenon. In great earthquakes the sound area is confined to the neighborhood of the epicenter; in moderate and slight shocks the sound area and disturbed area approximately coincide, or the sound area may even overlap the disturbed area. In the limiting case the disturbed area vanishes, and the vibrations are perceptible only as sound.

Accuracy of time very important.—Inasmuch as there is not any organized effort made to accurately observe earthquake phenomena in the United States, the popular and voluntary reports of such disturbances are alone available; but the

study of these is not fruitful of definite and conclusive results, owing both to the lack of information respecting details that can not be observed except by instrumental appliances, and to the need of greater exactness than can be expected from miscellaneous reports by untrained observers.

While the introduction of standard time and its general use throughout the country has greatly increased the value of the ordinary reports of the time of occurrence of an earthquake, yet the speed of propagation of seismic disturbances is so great that it can not be even approximately determined, unless the time is observed with a much greater degree of precision than is usual in the ordinary popular report. Very few people pay any regard to the second hands on their watches, and probably never use them, even if they wish to note the time accurately. Indeed, it will generally happen that there is a noticeable discordance between the second and minute hand of almost any watch one may please to examine. When the minute hand is exactly over one of the minute marks of the dial, the second hand should be exactly over the 60-point on its dial. In the majority of cases, however, the second hand will be found to be at other points on its dial, and a discordance of as much as thirty seconds may exist in this way. In using such a watch an accidental error of a whole minute of time may be made from this cause. Especially is this possible if one takes account of the position of the second hand and seeks to find the error of his watch by comparing it with some standard time. It is hoped that some of those who may read these remarks, and who may carry good watches (there are many such), will cultivate the practice of placing the minute and second hands in accord with each other when setting their watches. If at the moment of setting, the second hand is one-quarter, one-half, or two-thirds, etc., of the way around its dial, the minute hand should be set at one-quarter, one-half, or two-thirds, as the case may be, of the distance between the two proper minute lines on the dial where the hand is to be set.

In the case of earthquakes the exact time of the beginning of the disturbance, or better, of some pronounced maximum, and, if possible, a close determination of the duration of the whole series of oscillations constitute the most valuable features that can be noted by personal observation.

Direction of shock.—Much attention is often concentrated upon what seems to be the direction of propagation of the disturbance. An intimate knowledge of the nature of the actual movement of the earth at one's feet during an earthquake and of the manner in which surrounding objects are affected by such movements, will show how erroneous it is to suppose that the direction of progression of the disturbance can be determined by reference to such effects. In Japan, where earthquakes occur frequently, they have been made the subject of the most exact observation and measurement by instruments that give a complete trace of every phase of the earth's movement. From records thus obtained the exact movement of the earth at the instrument during every instant of the entire disturbance has been worked out for many earthquakes.

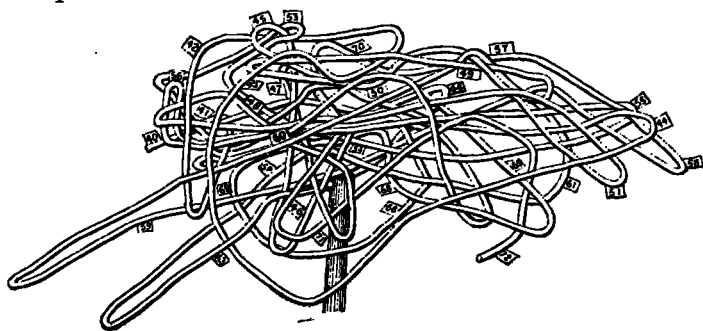


FIG. 1.

Figure 1 is a picture of a wire that has been so bent as to represent the recorded path of the ground and the instrument during a portion of one of these earthquakes. The wire takes up the record after the earthquake has been on for forty seconds, as is shown by the tag, No. 40, attached to the wire at this end. The other end of the wire comes out at the tag, No. 72, which marks the position of the earth particle at the seventy-second second of the disturbance. The wire shows the motion on a greatly magnified scale, the actual motion, being only a small fraction of an inch.

If the reader will follow closely the entangled windings of the wire he will acquire a comparatively correct idea of the extremely erratic and complex nature of the movement of the earth's surface at any point during a seismic disturbance. It must be plain also that motions occurring in such a confused snarl and in every possible direction, contain in themselves no evidence whatsoever of the direction of progression of the disturbance. Furthermore, when one reflects upon the effect such motions will have upon the walls of houses, which, it must be observed, are more susceptible to the influence of motions in some directions than in others, and therefore do not move precisely as the ground does; and when one considers, furthermore, the effect of these modified motions of the walls and floors upon suspended objects, such as pictures, mirrors, chandeliers, etc., or in causing the overthrow of insecure objects—it becomes apparent that the upsetting of an unstable vase, for example, in a certain direction, or the swinging of a mirror or chandelier after a certain fashion within a house can not be admitted to represent with any accuracy, either the nature of the motion of the earth immediately under the house where the observations are made, or the direction whence the wave came or whither it went.

Reports specifying direction of progression of the recent earthquake exhibit, as might be expected, marked discordance with each other in this respect. This element of the report, though sometimes given, is not regarded as of any special significance.

Speed of the wave.—The only means of ascertaining the speed and direction of motion of the earthquake wave is by a comparison and charting of the times of occurrence at different places. The trembling of the earth takes place at a later moment of absolute time the greater the distance from the real origin. In the case of the Charleston earthquake, the speed of the wave was worked out with great care by Capt. C. E. Dutton, of the Geological Survey, and found to be 3.22 miles per second.

Many more reports than those discussed herein could doubtless have been obtained had an effort been made to secure them, but the labor involved in such an undertaking (incident to the sifting of good reports from the bad, and to the laborious mathematical treatment necessary before results of even a fair degree of accuracy could be deduced from a large number of inferior observations) seemed entirely disproportionate to the profit to be gained, especially as the writer has been so closely occupied with other important investigations that but little time could be devoted to these earthquake studies. The present summary will impress the reader with the fact that the most important thing, by far, to observe at the time of an earthquake is the exact time of occurrence to the nearest second, if possible, and this time should, if possible, be the moment of some pronounced phase, such as the maximum of severity. The beginning and ending of an earthquake are a series of imperceptible tremors, and the times of beginning and ending are less definite and not as useful for study as the time of greatest violence, but should be observed, if possible. To merely note the time on one's watch, or other timepiece, is by no means sufficient. The timepiece must be compared at the earliest possible moment with some regulator, or other standard of time, and

allowance be made for the errors, not only of the watch or timepiece employed, but of the regulator itself. The best results are obtained when comparison can be made directly with the standard time signals telegraphed each day to almost every city and town. If an observer wishes his report of the time of occurrence of an earthquake to serve any useful purpose, he can not expend too much care in noting the exact minute and second, if possible, or at least the tenth of a minute, and in afterwards finding out exactly the error of the timepiece employed. A hundred accurately made time reports, over a region disturbed by an earthquake, would be more valuable than thousands in which the time is stated to be "about 6 a. m.," or "a few minutes after 6," or in which the time appears to be stated to the nearest five minutes only.

The earthquake of October 31.—Although at a few points within the region affected seismic instruments had previously been installed, yet from long inaction and neglect none of these were in condition to make a record when this earthquake finally came. There is a marked exception to this, however, in the case of the seismograph at the U. S. Weather Bureau at Washington, D. C., which faithfully made a perfect, and the only exact record of the time of occurrence of the disturbance at this place. The apparatus was fully described in the July REVIEW, and this is the second earthquake recorded since the installation of the instrument.

As recorded by this seismograph the time at Washington was 6 h. 13 min. 15 sec. a. m., seventy-fifth meridian time. Two other instrumental records of the time were obtained, respectively, one from the weighing rain gauge on the top of the Auditorium Tower in Chicago, and the other from a similar gauge on the roof of the post office in St. Louis. The times from these records, are 6.07 and 6.08, respectively. This instrument consists of a poised balance, so arranged, electrically, that a gradual accumulation of weight in a receptacle for collecting rain on one end of the balance causes the recording pen to mark on the register the total weight collected. When disturbed by agitations the balance will oscillate, and thus set up an electrical action that results in a record as if a small weight had been added to the receptacle. In the case of Chicago, with the gauge on the top of the lofty Auditorium Tower, the record indicated an effect equal to that produced by adding a weight of a little less than half an ounce to the collector of the gauge. The record at St. Louis, where the gauge is located upon a lower and consequently more stable building, showed an effect no more than one-third as great.

In order to reach some conclusion as to the validity of these records (similar ones being easily produced by wind and other causes), experiments were made with a gauge at Washington by mounting it upon a shaky table. The whole observed effect was easily reproduced by imparting to the table a vibratory motion, and particularly if this motion was not allowed to take place in any one plane nor be rhythmic in character, but was made to be irregular, jerky, and in all directions. It is believed that these experiments show the observed records to be unquestionably the result of an earthquake. Unfortunately, however, their value as time records is but slight, owing, first, to the fact that the time can not be obtained from the sheet to within less than one minute (= one-sixtieth of an inch on the scale of the record sheet); and, second, from the fact that the error in setting the sheet to standard time is unknown, and is easily liable to exceed a whole minute. In the case of the St. Louis record the official does not appear to have known that his rain gauge contained a record of the earthquake, and his report of the observed shock states a time two minutes later than shown on the record.

Although our observers frequently quote the times at which clocks were stopped by earthquake shock, yet but little weight can be given to these records in any investigation that aspires

to great accuracy, owing to the fact that violent disturbances often fail to stop a clock which is subsequently stopped by a very feeble shock. In general, when a clock is stopped by an earthquake it is liable to run irregularly for a considerable number of beats before actually stopping, as any one can demonstrate for himself by experiment on his own clock; moreover the error of the stopped clock is generally unknown.

A critical examination of all the time reports shows that by far the greater part of them are so inexact as to be of no value whatsoever in fixing the speed of the wave. A few, only, can pass the requirements of good observations. Many people in noting time consider only the nearest five minutes, and this practice is clearly apparent in the reports. Out of 264 reports, 196 express the time as "about 6," "a few minutes after 6," or as some multiple of 5. While it is not impossible that some of these times may be as trustworthy as others which are regarded as better, the probabilities are that the number of these must be quite small, and it is impossible to tell which they are. Furthermore, as the time at Washington is unquestionable, and as it is probably the most distant point at which the shock was felt, all other accepted times must not be later than this. Moreover times earlier than 6.00 can not be regarded as relating to the shock in question. On this score 94 reports must be rejected. Of those that remain, 58 give the time as about 6 o'clock, or a few minutes after 6, or are otherwise too indefinite to be accepted.

This course of selection leaves 112 reports yet to be dealt with. Of these, 46 state the time to be "6.05" and "6.10," and none of these contain internal evidence that the time is to the nearest minute rather than to the nearest five minutes.

There does not appear to be any rational basis by which these times can be properly incorporated with the others, and they also must, therefore, be rejected. The reports that remain arrange themselves, curiously enough, in two groups, one on the time 6.07 or 6.08, the other on the time 6.12. The idea that there might have been two shocks about five minutes apart is not sustained by the detailed accounts.

The following reports of the time were accompanied by such explanations as to the manner of observing, the comparison of watches, etc., as to render them the most exact measurements obtained:

Cairo, Ill., W. T. Blythe, L. F. O., 6 hr. 7 min. 30 sec.

Rock Island, Ill., J. A. Udder, observed ending, 6 hr. 11 min. 45 sec.; duration about fifty seconds.

Mount Vernon, Iowa, Miles E. Mitchell, 6 hr. 11 min. 30 sec.

Mount Vernon, Iowa, W. H. Norton, 6 hr. 12 min. 10 sec.

Washington, D. C., Weather Bureau, seismograph, 6 hr. 13 min. 15 sec.

The following times are reported with some appearance of accuracy, but not enough detail is given to justify us in assigning them the first rank:

Corning, Ark., 6 hr. 8 min. 30 sec. to 6 hr. 10 min. 0 sec.

Anderson, Mo., 6 hr. 10 min. 48 sec.

Blaine, Kans., 6.15 to 6.17.

Pleasure Ridge, Ky., 6 h. 8 min. 45 sec.

Glasgow, Mo., 6.13.

Milan, Tenn., 6.09 to 6.10.

Warrenton, Mo., between 6.08 and 6.09.

Golconda, Ill., 6.02 to 6.03.

Abstracts of observers reports.—The reports show the disturbance to have been felt, more or less, throughout the following States: Alabama, Arizona, District of Columbia, Georgia, Illinois, Indiana, Kentucky, Maryland, Michigan, Mississippi, Nebraska, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, and Wisconsin.

The reports of the severity of the shock do not allow any definite conclusion to be reached as to its approximate origin or region of greatest violence. In a general way the region

in the vicinity of and northeast of the junction of the Ohio and Mississippi rivers seems to have experienced the strongest shocks. The lack of definite knowledge on this point constitutes a further difficulty in the analysis of the time reports, which are too small in number or too inexact in character to indicate in themselves the center of the disturbance.

The following extracts from reports of the regular Weather Bureau observers will afford an idea of the character of the shock in the different sections affected (these records are all converted into seventy-fifth meridian time):

Augusta, Ga.—Shortly after 6 a. m. to-day a number of persons felt a slight earthquake shock, which, from all accounts, lasted about a second or two; the tremor was just perceptible by the rattling of windows; direction of vibration could not be ascertained.

Cairo, Ill.—A severe earthquake shock occurred a few minutes after 6 a. m. The time, as determined by the local forecast official by comparing his watch with seventy-fifth meridian time later in the day, was between 6.07 a. m. and 6.08 a. m., seventy-fifth meridian time. The local forecast official was in bed at the time the shake began, but was fully awake. Its duration, as estimated by considering his movements from the time it began till it ended, and also from the experience of others, including Mr. J. W. Byram, Observer, is believed to have been from thirty-five to forty-five seconds. There is great diversity of opinion as to the direction of the waves, if waves there were. The majority of persons, however, claim that the movement was from east-northeast to west-southwest. The fact that the local forecast official, raised himself on his elbow, remaining in that position some time, then arose, felt his way (it was dark) around the foot of the bed to the dresser, and lighted the gas during the occurrence, without feeling any oscillatory motion, causes him to believe that the shock was a severe tremor. No noise, other than that of the cracking and creaking timbers in the house, the rattle of crockery and glassware, and the falling and breaking of parlor and dresser ornaments, was heard. The losses due to broken china and glassware, ornaments, etc., aggregate quite a considerable sum. The number of chimneys shaken down in the city probably runs into the hundreds. The plaster in nearly all frame buildings was more or less damaged. But the brick and stone buildings suffered the most serious damage, though none fell and probably none were rendered uninhabitable. The following are a few of the injured buildings: The county court house, chimneys above the roof shaken down; walls badly cracked. The large brick office building belonging to and occupied by the Cairo Trust Co., chimneys fell, slate roofs damaged, walls cracked. The Safford Public Library, walls badly cracked and the front gable parted from the roof; left standing, but in a dangerous condition, and will have to be removed and replaced. St. Joseph's Catholic Church, brick steeple cracked and twisted; will have to be removed and rebuilt at an estimated cost of \$1,000 to \$1,200. The United States custom house (stone), old cracks opened and new ones made. A large number of buildings in the downtown business district were damaged by walls being cracked and plate glass fronts broken.

Charleston, S. C.—Light earthquake shock at 6.04 a. m.; light tremors and vibrations lasting about eight seconds.

Charlotte N. C.—An earthquake shock was felt by several persons in the city at 6.15 this morning, the vibration lasting about ten seconds. The shock was extremely light and was felt by so few persons that it was not positively known that it was an earthquake shock until in the evening, when dispatches were received by the newspapers stating that the shock had been noticed at other points. The direction of the vibration was not noticed.

Chattanooga, Tenn.—An earthquake shock was felt in this city at 6.10 a. m. to-day; motion east and west; duration of the vibration, thirty seconds. No effect in this city outside of shaking chandeliers, rocking off ouses, rattling of windows, and rocking of beds.

Chicago, Ill.—An earthquake shock was felt in the morning at about 6.07 a. m. all over the city. The rain gauge register shows a decided jar at that time, no doubt caused by the shock. The shock was also felt at Downers Grove, about 15 miles west of the city on the Burlington road. The shock lasted from fifteen to thirty seconds.

Cincinnati, Ohio.—An earthquake shock was very generally felt in this city at 6.05 a. m. Two distinct waves of motion, apparently from south to north, were felt in quick succession. Buildings wavered, furniture was moved, windows rattled, and beds (in which most people at that early hour were still resting) rocked like cradles. Clocks were stopped, pointing to 6.05 a. m. While a great deal of alarm and consternation was created by the tremble, no injury or serious damage was sustained.

Columbia, Mo.—A slight earthquake shock was felt at 6.08 a. m. No damage reported.

Columbia, S. C.—There was a slight earthquake shock felt between 6.15 and 6.30 a. m. It was not severe enough to awaken persons sleeping, but was very perceptible to those who were awake. The vibrations lasted about thirty seconds, and from the swaying of oil in a lamp by my bedside it was thought that the wave direction was north and south.

Concordia, Kans.—A slight shock of earthquake was felt in this city at 6.12 a. m. Mr. James, train dispatcher at the Central Branch Railroad, who was on duty at the time, states that there were three distinct shocks, about fifteen seconds apart.

Davenport, Iowa.—A moderate earthquake shock was felt this morning about 6.12 o'clock. The direction, amplitude, or intensity of the seismic disturbance could not be determined.

Des Moines, Iowa.—There is said to have been a slight earthquake at about 6.00 a. m. Three shocks are reported, the waves moving from east to west.

Fort Smith, Ark.—A very slight earthquake shock was felt by a few individuals here at a few minutes past 6 o'clock a. m., but without any rumbling noise. Of about fifty persons asked relative to the shock only two stated that they felt it—Dr. Hatchett, a practising physician, and Mr. W. Abbot, lumber merchant. Dr. Hatchett reports the motion as lateral, but does not know the direction of movement; Mr. Abbot states the movement was toward the west. The Weather Bureau observer did not feel the shock.

Grand Haven, Mich.—Sharp earthquake shock felt this morning about 6.20, the vibrations lasting fully one minute. No damage was done.

Hannibal, Mo.—A seismic disturbance, or earthquake shock, was very perceptibly felt at this station at 6.12 to 6.13 a. m., lasting fully one minute, and causing some damage to brick buildings by cracking the walls.

Indianapolis, Ind.—An earthquake occurred about 6.11 a. m., lasting about four seconds. I did not feel it, but Mr. Albright, who takes the a. m. observation, reports that he felt the first shock very distinctly at 5.11 a. m. He could feel a trembling for about four seconds, and then he felt a second shock, then he felt trembling for about two seconds, and then a third shock. The second shock was the strongest; no trembling was felt after the third shock. In the city and State most people were awakened by the disturbance. No damage was done in the city.

Kansas City, Mo.—Two very distinct earthquake shocks were felt at 5.12 a. m., lasting about one-half a minute. It was general in this locality, and from newspaper reports, extended over a wide belt. The official in charge of station was not awakened by it, nor any member of his family. Mr. Young, an assistant, and his family were not disturbed. Mr. Coup and Mr. Hall, assistants, distinctly felt the vibrations as though some persons were under their beds, moving them. Some parties who are supposed to know more than others about such matters, state that the vibrations were vertical. Not the least suggestion of damage in this part of the country.

Keokuk, Iowa.—At 6.15 a. m. a slight earthquake shock was felt, preceded by low, rumbling sounds. Motion from south to north, lasting about ten seconds, then an interval of about ten seconds and a second motion of about ten seconds felt; motion swaying light objects, such as lamp shades, hanging pictures, &c.

Knoxville, Tenn.—About 6.00 this morning several distinct shocks of earthquake are reported to have been felt all over this city, more particularly on the outskirts of the town. The shocks are reported to have been from east to west and were very perceptible.

Little Rock, Ark.—Distinct earthquake, the vibrations being east and west and lasting about one minute, occurred at 6.15 a. m. Shock was also felt at Forrest City, Helena, Brinkley, and several other points in eastern Arkansas.

Louisville, Ky.—Three distinct and very severe earthquake shocks were experienced this morning. The first occurred at 6.07 a. m., and was followed a few seconds later by a second, and, after a brief interval, by the third and most violent. While no serious damage resulted, the vibrations were of sufficient force to cause the ringing of bells, the rocking of articles of furniture, and the displacing of ornaments and other articles from tables and mantels. The disturbance appeared to proceed from the northwest toward the southeast. A number of persons state that a slight shock occurred shortly after midnight, and many report that the main shock this morning was accompanied by a brilliant flash of light, resembling lightning. The earthquake was very general throughout Kentucky and was apparently most severe in the extreme western counties.

Memphis, Tenn.—An earthquake shock of considerable severity was felt in this city this morning shortly after 6 o'clock. A careful comparison of time by a number of competent observers shows that the vibrations from the first shock ceased at 6 hr. 07 min. 30 sec. a. m., having lasted about thirty seconds. A secondary shock or vibration was observed at 6 hr. 14 min. 00 sec. by a number of reliable observers, though not by all. There was no damage done in this city, except to two chimneys in the suburbs, which were shaken down.

Meridian, Miss.—Light earthquake shock said to have been felt in the early morning.

Montgomery, Ala.—Light earthquake felt in the city at 6.30 a. m. today; windows rattled and beds were shaken; no damage. The reports from different towns in the State show the earthquake to have been felt throughout the State.

Nashville, Tenn.—An earthquake visited the city about 6.05 a. m.

Omaha, Nebr.—Shortly after 6 o'clock this morning a slight earthquake shock was reported by reliable persons to have been felt in this city. The shock was not felt by any of the station force. No damage from the shock was reported.

Parkersburg, W. Va.—At 6.15 a. m., several (about three) distinct earthquake shocks were felt. The first shock was the most severe, and was followed by long, gentle undulations, having directions from southwest to northeast, as nearly as could be told.

Pittsburg, Pa.—A slight earthquake shock was felt at Bellevue and McKeesport, suburbs of Pittsburg, at 6 a. m. The shock produced only a very slight jar and a slight movement of pictures, etc., hanging on walls, and continued but a few seconds.

St. Louis, Mo.—A slight shock of earthquake was felt at 6.10 a. m., lasting about fifteen seconds. The direction of vibration was from east to west. No damage of consequence reported.

Springfield, Ill.—Quite a distinct earthquake shock, or series of shocks, was felt in the vicinity at exactly 6.16 a. m. It was accompanied by a rumbling sound, and was sufficiently strong to rattle windows. The apparent movement was from west to east. It lasted about fifteen seconds.

Springfield, Mo.—At 6.13 an earthquake shock was felt. The vibrations apparently were from the east to the west, and lasted about five seconds. It was accompanied by a sharp report and a rumbling noise. This rumbling noise was heard for twenty seconds after the shock was felt, and seemed to grow fainter and fainter, like the passing of a railroad train. No damage resulted in this locality from the phenomenon.

Toledo, Ohio.—Earthquake shock felt at 6.12 a. m.; no damage.

Topeka, Kans.—An earthquake shock about 6.12 a. m., but the observer was not awaked by it, though a large number of citizens were.

Vicksburg, Miss.—An earthquake shock was reported, upon reliable authority, in the vicinity of station at 6.03 a. m. Its duration was fifteen to twenty seconds, and was apparently continuous. It was accompanied by no unusual noise. The word moderate would best describe its intensity, and there was no other cause for what happened than an earthquake.

Observed times of occurrence of earthquake of October 31.

Stations of Weather Bureau.	Time—75th meridian.	Stations of Weather Bureau.	Time—75th meridian.
Augusta, Ga.	Shortly after 6.00.	Louisville, Ky.	6.07.
Cairo, Ill.	Between 6.07 & 6.08.	Memphis, Tenn.	6.07.
Charleston, S. C.	6.04.	Montgomery, Ala.	5.30.
Charlotte, N. C.	6.15.	Nashville, Tenn.	About 6.05.
Chattanooga, Tenn.	6.10.	Omaha, Nebr.	Shortly after 6.00.
Chicago, Ill.	About 6.07.	Parkersburg, W. Va.	6.15.
Cincinnati, Ohio	6.08.	Pittsburg, Pa.	6.00.
Cleveland, Ohio	About 6.15.	St. Louis, Mo.	6.10.
Columbia, Mo.	6.08.	Springfield, Ill.	6.16.
Columbia, S. C.	Between 6.15 & 6.30.	Springfield, Mo.	6.13.
Columbus, Ohio	About 6.12.	Toledo, Ohio	6.12.
Concordia, Kans.	6.12.	Topeka, Kans.	About 6.12.
Davenport, Iowa	About 6.12.	Vicksburg, Miss.	6.08.
Des Moines, Iowa	About 6.00.	Washington, D. C.	6 ^h 13 ^m 15 ^s .
Fort Smith, Ark.	Few min. after 6.00.	Various sources.	
Grand Haven, Mich.	About 6.20.	Mt. Vernon, Iowa	6 ^h 11 ^m 30 ^s .
Hannibal, Mo.	6.12 to 6.13.	Do.	6 ^h 12 ^m 10 ^s .
Indianapolis, Ind.	About 6.11.	Centerville, Ind.	About 6.30.
Kansas City, Mo.	6.12.	Evansville, Ind.	6.12.
Keokuk, Iowa	6.15.	Rock Island, Ill.	Observed ending 6 ^h 11 ^m 45 ^s ; duration about 50 seconds.
Knoxville, Tenn.	About 6.00.		
Little Rock, Ark.	6.15.		

Reports by voluntary observers of the Weather Bureau.

Voluntary observers.	Time—90th meridian.	Voluntary observers.	Time—90th meridian.
Alabama.		Illinois—Cont'd.	
Birmingham	4.00.	New Burnside	5.10, very heavy.
Madison	5.00.	Olney	5.09.
Tuscaloosa	About 5.10.	Ottawa	5.10.
Union	About 5.00.	Palatine	5.30.
Arkansas.		Peoria	5.10.
Brinkley	5.10.	Rantoul	5.15.
Forest City	5.15.	Carlin	5.00.
La Crosse	5.15.	Cazenovia	Light, about 5.05.
Osceola	5.10.	Catsburg	5.12.
Pocahontas	5.00.	Decatur	5.12.
Helena	5.15.	Flora	5.05, severe.
Corning	Ret. 4 ^h 30 ^m 30 ^s & 5.10.	Friend Grove	5.15.
Georgia.		Galva	5.09.
Dahlonega	5.30.	Gilman	5.15.
Griffin	5.50.	Golconda	5.02 to 5.08, very heavy.
Lagrange	5.00.	Greenville	5.07.
Rome	5.15.	Havana	5.15.
Illinois.		Hillsboro	5.10.
Albion	5.00, heavy.	Iron	About 5.30, very heavy.
Alexander	5.00.	Jordan Grove	About 5.05.
Atlanta	5.15.	Lamar	5.10.
Atwood	5.00, severe.	Lexington	5.15.
Alwood	5.00.	Reynolds	3.00 to 5.00.
Beardstown	Slight, about 5.00.	Rockford	5.20.
Bushnell	About 5.15.	Tuscola	About 5.15, heavy.
Carlinville	5.10, severe.	Winnebago	5.00.
Carrollton	5.12.	Indiana.	
Louisville	5.07.	Anderson	5 ^h 10 ^m 48 ^s .
McLeansboro	5.12.	Bluffton	4.55.
Martinsville	5.15.	Buttleville	About 5.00, severe.
Mattson	5.10, quite heavy.	Cambridge City	5.10.
Mount Pulaski	5.15.		
Mount Vernon	5.10.		

Reports of voluntary observers—Continued.

Voluntary observers.	Time— 90th meridian.	Voluntary observers.	Time— 90th meridian.
Indiana—Cont'd.		Missouri—Cont'd.	
Columbus.....	5.05.	Fayette.....	5.15.
Connorsville.....	5.10.	Fulton.....	5.00.
Delphi.....	5.15.	Gayoso.....	About 5.00.
Edwardsville.....	Shortly after 5.00.	Glasgow.....	5.15.†
Evansville.....	5.09.	Gordonsville.....	5.15.
Farmland.....	5.15.	Half Way.....	4.00.
Huntingbury.....	5.15 heavy.	Hermann.....	5.12.
Huntington.....	About 5.00.	Houston.....	About 5.20.
Jasper.....	About 5.18.	Houstonia.....	5.12—5.15.
Jeffersonville.....	5.28.	Ironton.....	5.15.
Kokomo.....	5.10.	Kidder.....	5.10.
Lafayette.....	5.12 to 5.15.	Lamonte.....	5.15.
Logansport.....	5.15.	Lebanon.....	5.15.
Lyford.....	About 5.00.	Lexington.....	5.14.
Madison.....	At 5.00.	Liberty.....	Few min. before 5.14
Marion.....	5.10.	McCune Station.....	5.12.
Mount Vernon.....	5.15, severe.	Marcelline.....	5.00.
Princeton.....	5.15, severe.	Maryville.....	5.15.
Rockville.....	5.15.	Mexico.....	5.10.
Scottsburg.....	About 5.00.	Mine La Motte.....	5.05.
Seymour.....	5.10.	New Haven.....	5.15.
South Bend.....	Few min. after 5.00.	New Madrid.....	5.14, heaviest since 1811.
Syracuse.....	5.10.	New Palestine.....	About 5.00.
Terre Haute.....	5.13.	Oakfield.....	5.15.
Topeka.....	5.00.	Oak Ridge.....	4.00.
Valparaiso.....	About 5.15.	Oregon.....	5.00.
Vevay.....	5.10, strong.	Do.....	5.15.
Iowa.		Palmyra.....	5.15.
Ames.....	5.20.	Poplar Bluff.....	5.10.
Cedar Rapids.....	Little past 5.00.*	Potosi.....	5.10.
Chariton.....	5.10.	St. Charles.....	5.14.
Dubuque.....	5.15.	Shelbina.....	5.15.
Fairfield.....	5.00.	Sikeston.....	5.05.
Fort Madison.....	Few min. past 5.00.	Steffenville.....	5.10.
Glenwood.....	About 5.00.	Trenton.....	5.10 to 5.15.
Grinnel.....	5.20.	Unionville.....	5.10 to 5.13.
Iowa City.....	5.07.	Vermont.....	5.10.
Marshalltown.....	About 5.00.	Vilas.....	5.20.
Moran.....	4.50.	Virgil City.....	About 5.00.
Mechanicsville.....	5.12.	Warrensburg.....	3.00 and 5.00.
Moor.....	5.05.	Warrenton.....	5.09 to 5.09.
Mount Pleasant.....	5.18.	Willow Springs.....	5.00.
Mount Vernon.....	5.13.	Zeitonia.....	5.00.
Ottumwa.....	5.05.	Nebraska	
Sydney.....	5.10.	Burchard.....	5.07.
Winterset.....	5.30.	North Carolina.	
Kansas.		Lenoir.....	About 5.00.
Blaine.....	5.15 to 5.17.	Skyuka.....	Between 5.00 & 6.00.
Frankfort.....	5.10.	Waynesville.....	About 5.10.
Manhattan.....	5.15.	Ohio.	
Wamego.....	5.15.	Bellefontaine.....	About 5.15.
Kentucky.		Camp Dennison.....	5.10.
Alpha.....	5.10, violent.	Cleveland.....	About 5.15.
Blandville.....	About 5.15, very severe.	Dupont.....	5.15.
Bowling Green.....	Few min. after 5.00.	Fayetteville.....	5.00.
Canton.....	5.15.	Greenville.....	Between 4.00 & 5.00.
Earlington.....	5.10.	Hanging Rock.....	5.15.
Edmonton.....	5.30.	Hillsboro.....	Little aft. 5.00.
Falmouth.....	5.15.	Leipsic.....	5.23.
Fords Ferry.....	5.45, (sun time.)	McConnellsville.....	5.00.
Franklin.....	5.09.	Montpelier.....	About 5.12.
Henderson.....	5.12, very severe.	New Bremen.....	5.30.
Paducah.....	5.12.	New Paris.....	5.00.
Pleasure Ridge Pk.....	5 ^h 45'.	Ottawa.....	5.20.
Princeton.....	5.08.	Portsmouth.....	5.12.
Michigan.		Vanceburg.....	5.15.
Battle Creek.....	5.15.	Van Wert.....	5.05.
Berrien Springs.....	4.00 or 5.00.	Waverly.....	5.12.
Grand Rapids.....	About 5.00.	Oklahoma.	
Hanover.....	About 5.00.	Pond Creek.....	In the a. m., slight.
Kalamazoo.....	5.10.	Tennessee.	
South Haven.....	5.00.	Ashwood.....	5.20.
Mississippi.		Bollivar.....	5.15.
Aberdeen.....	About 5.00.	Covington.....	About 5.00.
Austin.....	5.00.	Dyersburg.....	5.08.
French Camp.....	About 5.00.	Franklin.....	5.15.
Fulton.....	5.00.	Hohenwald.....	About 5.00.
Hernando.....	About 5.00.	McKenzie.....	5.10.
Holly Springs.....	5.15, heavy.	McMinnville.....	5.11.
Louisville.....	About 5.00.	Millan.....	5.09 to 5.10.
Mayersville.....	4.45.	Mount Carmel.....	About 5.00.
Pontotoc.....	5.00.	Palmetto.....	4.00.
Water Valley.....	5.02.	Riddleton.....	Between 4.00 & 5.00.
Missouri.		Sewanee.....	About 4.00.
Birch Tree.....	5.10.	Trenton.....	5.15.
Bluffton.....	5.05.	Wisconsin.	
Edgehill.....	5.25.	De Pere.....	5.15.
Eight Mile.....	5.30.		

*As recorded on the thermograph sheet. †The Observer, C. W. Pritchett, is director of the Morrison Observatory at Glasgow.

PHOTOGRAPHING LIGHTNING BY DAYLIGHT.

By A. J. HENRY Chief of Division of Records and Meteorological Data (dated January, 1896).

It is a common observation by those who have closely watched lightning flashes of the linear zigzag type that the flash sometimes appears to repeat itself in substantially the same path, or to pour forth a continuous stream from cloud to earth for an appreciable time. As long ago as 1835 Dove satisfied himself that single flashes of lightning often consisted of a number of apparently instantaneous discharges. Frequent attempts have been made, principally by Prof. Rood, by the aid of a revolving disk with colored or numbered sectors, to determine the duration of flashes of the several types. The duration of the complete act has been found to vary from less than $\frac{1}{1000}$ of a second to a whole second, although the individual flashes occupy but a few thousandths of a second.

Photographs of lightning flashes have been made by many persons during the night time, but, so far as known, a flash has never been photographed during daylight hours. Considering that flashes of the multiple-discharge character continue for an appreciable time, it has often occurred to me that under favorable conditions it would be possible to make a negative of a flash of this character.

On September 19, 1895, the conditions long looked for occurred. The heavens were completely overcast, and although it was about 2 o'clock in the afternoon, the actinic power of the light was so reduced that it was possible to expose a sensitive plate of a slow emulsion for half a second with full aperture of the lens without seriously "fogging" it.

The camera was pointed toward that particular point of the heavens whence a flash was expected, the dark slide drawn, and, the moment a flash appeared visible in the field of view, the shutter was opened by the observer and held open possibly for a quarter of a second or longer. Four plates were thus successively exposed, three without results, but on the fourth trial a flash was obtained.

The image secured was sharp and distinct, but the remainder of the plate was of such density that it would be exceedingly difficult to reproduce the flash satisfactorily by means of the half-tone process.

The negative shows four distinct flashes, while a fifth is faintly visible. These, no doubt, are only a portion of the whole number of separate and successive discharges included in the complete act. The total duration of the successive discharges, as estimated by the unaided vision, was not far from two-fifths of a second.

The most striking feature of the flash is the width of the path of discharge. A comparison of the size of the image with that of the Washington Monument in the same field of view, and whose dimensions are known, enables us to determine with a fair measure of accuracy the angular width of the flash. The only uncertainty as to its linear dimensions arises from the fact that the distance of the flash from the camera is not known. If it occurred at the same distance as the Monument, the width of the bottom portion of the path of discharge would be about 20 feet. It is believed, however, that the flash was at some distance beyond the plane of the Monument, and that the width given above is too small.

NOTES BY THE EDITOR.

THE GREAT STORM OF OCTOBER, 1896, IN THE GULF OF CALIFORNIA.

About midnight of September 30 a hurricane wind began at La Paz, at the lower end of the Peninsula of California,

and continued until 5 p. m. of October 1. This storm totally destroyed the city, and did much damage to the shipping. Reports from Guaymas, Mexico, state that the hurricane moved slowly northward during four days, September 30 to